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Author(s): Richard S. Prawat
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Teachers' Beliefs about Teaching and Learning: A Constructivist Perspective

RICHARD S. PRAWAT
Michigan State University

Teachers are viewed as important agents of change in the reform effort currently under way in education and thus are expected to play a key role in changing schools and classrooms. Paradoxically, however, teachers are also viewed as major obstacles to change because of their adherence to outmoded forms of instruction that emphasize factual and procedural knowledge at the expense of deeper levels of understanding. New constructivist approaches to teaching and learning, which many reformers advocate, are inconsistent with much of what teachers believe—a problem that may be overcome if teachers are willing to rethink their views on a number of issues. This article seeks to advance this cause by identifying important aspects of current thinking that may get in the way of teachers adopting a constructivist approach to teaching and learning.

We are in the midst of a major paradigm shift in education. One commentator argues that the current ferment constitutes "a revolution" (Goldman 1989). It represents, he adds, "one of those rare periods in history when large numbers of people are receptive to major changes in education" (p. 47). This interpretation is supported by results from the most recent Gallup poll in education sponsored by Phi Delta Kappa. For the first time in its 20-year history, the poll shows the public favors drastic overhaul of our educational system—including the adoption of a national curriculum and national educational standards (Elan and Gallup 1989). As was the case 30 years ago, this critical attitude is both a symptom and a cause of important changes in the way we view education. It reflects the growing concern that our students are losing out in the schooling race—a belief supported by the results of several international surveys. In math and science, in particular, U.S. students lag far behind students in other countries at every grade level. Because of these concerns, educators are being asked to reexamine their practice.

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Rather than imitate systems like those in Japan, Taiwan, or Korea, with their strong reliance on external incentives (e.g., highly competitive national exams), many reformers are calling for a more creative response to our educational dilemma. Their arguments mirror those made by reformers in the private sector, who cite the now well established relationship between worker autonomy and control and the amount of productivity and commitment to the workplace on the part of employees. One business leader states the case as follows: "The idea of liberation and empowerment for our work force is not enlightenment, it's a competitive necessity" (Sherman 1989). There is evidence that a similar argument is beginning to prevail in education. Thus, McDonald (1988) points to a clear difference between what he terms the first and second phases of the current school reform movement: "Whereas the key 1983 report, *A Nation at Risk,* implicitly took teachers to be dumb instruments of school policy, the key 1986 report, that of the Carnegie Task Force, takes them to be its chief agents" (p. 471).

McDonald attributes this change in perspective to a number of factors, including recent policy studies that call into question diffusion-adoption conceptions of educational change. In these models, practitioners are cast in the role of passive receivers of innovation. Current research challenges this view, regarding teachers as important participants in policy implementation. As indicated, this represents an important shift in reform strategy, from top-down control to teacher empowerment (Porter et al. 1990).

Teacher Empowerment

Teacher empowerment is a popular but slippery concept, perhaps because it encompasses both political and epistemological agendas (Prawat 1991*a*). McDonald (1988) captures this dual meaning in his discussion of "teacher voice," a concept that falls under the empowerment rubric. "*Voice* may refer to the right and power to have a say in policy," he writes, "but it may also refer to the content of what might be said, and implicitly to what those who are empowered to

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RICHARD S. PRAWAT is professor in the departments of teacher education and counseling, educational psychology, and special education. He is also chairman of the Department of Counseling, Educational Psychology, and Special Education. His research focuses on student motivation and teaching and learning for understanding.

speak *know*" (p. 472). Those who seek to empower teachers often focus on either political or epistemological goals. From a political perspective, the most important empowerment goal is to increase teachers' professional authority, particularly as it relates to issues of curriculum and instruction (Prawat 1991*a*). Too often, according to this perspective, teachers are pressed to do things—to add more material to an already-crowded curriculum, for example, or to maintain "well-disciplined" classrooms—that they regard as detrimental to student learning. "At the heart of the concept," write Porter et al. (1990), "is the belief that qualified and committed teachers, given decision-making power, will do the right thing" (p. 20).

What constitutes the "right thing," of course, is a matter of judgment or opinion. As such, it is strongly influenced by a host of factors that are more endogenous to teaching, such as teachers' views of teaching and learning (Carlsen 1987; Smith and Neale 1989). The argument goes something like this: Teachers' views of teaching and learning influence their classroom practice. Currently, these beliefs support traditional practice, best characterized as a "transmission" approach to teaching and an "absorptionist" approach to learning. As Cohen (1988*b*) puts it, teachers traditionally are seen as "tellers of truth who inculcate knowledge in students" (p. 15). Students play a relatively passive role: They are "accumulators of material who listen, read, and perform prescribed exercises" (p. 15). These views of teaching and learning constitute an important obstacle in attempts to change normal patterns of classroom interaction (Cohen et al. 1990). Challenging these beliefs thus becomes a major goal in empowerment—and in the educational reform movement more generally.

Stimulating teachers' thinking about teaching and learning, the kind of thinking that "summons alternative realities for those sunken in what seems given" (Greene 1986, p. 78), has the same empowerment potential as working to gain a professional voice for teachers. Both the political and epistemological agendas seek to create new opportunities for teacher growth and change. Those who pursue either must be pragmatic as regards means and ends. Epistemologically, the teacher educator must walk a fine line, arguing that science does turn up better ways of construing reality—"successively better instruments for discovering and solving puzzles," as Kuhn puts it (in Rorty 1982, p. 9)—but this does not mean that we are moving closer to "objective truth." New theories are not better because they correspond more closely to reality, but because they allow us to address a new and more vexing set of problems (Rorty 1982). New theories direct attention to important aspects of the environment that otherwise would go unnoticed. In a sense, they help "educate" attention (Gough 1989). This notion

about the role of theory is consistent with the word's etymological roots, which can be traced back to the Greek "theamai," or "I behold," suggesting that theories do heighten one's perceptual awareness (see Coles 1989).

Being provided with a new set of theoretical or conceptual "lenses" can be empowering for teachers, but it also complicates their lives. This is particularly true of constructivist theory. While there are several interpretations of what this theory means, most agree that it involves a dramatic change in the *focus* of teaching, putting the students' own efforts to understand at the center of the educational enterprise. The adoption of such an approach to teaching and learning, as I will argue in this article, would result in major changes in the teacher's role. Thus, in all constructivist teaching-learning scenarios, the traditional telling-listening relationship between teacher and student is replaced by one that is more complex and interactive. It is not surprising that constructivist teaching places greater demands on teachers (and students). As Cohen (1988*a*) points out, "Teachers who take this path must work harder, concentrate more, and embrace larger pedagogical responsibilities than if they only assigned text chapters and seatwork" (p. 255). Teachers are unlikely to complicate their lives in this way without undergoing a significant change in their thinking.

Getting people to change beliefs, especially intuitively reasonable ones, is a difficult proposition. Recent research on the conceptual-change process indicates that several criteria must be met: First, individuals must be dissatisfied with their existing beliefs in some way; second, they must find the alternatives both intelligible and useful in extending their understanding to new situations; third, they must figure out some way to connect the new beliefs with their earlier conceptions (Posner et al. 1982).

In this article, I will discuss four questionable sets of beliefs about teaching and learning. These beliefs can be briefly characterized as follows: First, there is the tendency to think of both learner and content as relatively fixed entities—givens that somehow must be adjusted to in their present form. The fact that teachers view content and students in static, noninteractive terms explains why so much time and attention is devoted to the *delivery* of content instead of more substantive issues relating to content selection and meaning making on the part of students. In the context of a fixed set of curricular demands, variation in the style and pace of instruction may be perceived as the only way to accommodate what are regarded as equally hard and fast individual differences. The second set of beliefs, termed "naive constructivism," is just as problematic from a constructivist perspective: This is the tendency to equate activity with learning—a notion that Dewey at-

tempted to counter. He argued that student engagement is not the best measure of educational value.

The third set of beliefs perpetuates a distinction that I, as a constructivist, would like to do away with: that between comprehension and application, learning and problem solving. This set of beliefs may be the most intractable of the four under consideration. The comprehension-application distinction is intuitively appealing and supported by the research on transfer; it has also been legitimated in various taxonomies of educational outcomes. The fourth set of beliefs relates to curriculum: This is the popular view of curriculum as a fixed agenda, a daily course to be run that consists of preset means (i.e., certain material to cover) and predetermined ends (i.e., a discrete set of skills or competencies). Many constructivists, myself included, favor a more interactive and dynamic approach to curriculum, believing that it should be viewed more as a matrix of ideas to be explored over a period of time than as a road map. One would enter this matrix at various points, depending on where students are in their current understanding.

The four sets of beliefs described above are at the core of the educational enterprise. As it will be shown, they influence many aspects of teacher behavior. For this reason, and because they underlie traditional, transmission approaches to teaching and learning, they should be considered high-priority candidates for conceptual change. In the next section, I will briefly compare the current reform effort to the one that took place 30 years ago, arguing that the views of teaching and learning being advanced now differ in important ways from those that prevailed in the 1960s.

A Glance Back: Educational Reform in the 1960s

The nature of the discourse differed 30 years ago—with national security concerns being foremost in everyone's mind—but the argument for educational reform was similar: We have lost our technological superiority because of deficiencies in the educational system. At that time, the problem was thought to result from insufficient attention to disciplinary knowledge and/or process in our schools. The most direct way to address this problem, the argument went, was to change the nature of the curricular material used in public schools. This led to the development of a great deal of innovative curricula, most of it emphasizing one of two worthy goals: developing a deeper understanding of the substantive structure of the discipline (i.e., the concepts and principles thought to lie at the core of each of the school-related disciplines), *or* getting students to become more proficient generators

and users of knowledge. The focus on this second goal was "syntactic," intended to provide students with the inquiry and problem-solving skills used by scholars in each of the disciplines.

Most disagreements in educational philosophy during the 1960s, as in previous reform movements, were handled by variations on the familiar themes of subject-centered and learner-centered approaches to instruction. As Petrie (1981) points out, these approaches are at the center of disagreements about the nature of schooling that go way back in the history of educational discourse. Post-Sputnik reformers stayed well within the boundaries of this argument, emphasizing either truth-oriented intellectual objectives (based on the substance of the discipline) *or* more general processes of inquiry, problem solving, and decision making (based on the syntax). The former is consistent with the subject-centered approach, the latter with the learner-centered approach to education. Whitson (1985) characterizes this as a debate centering on the issue of whether curriculum should foster "truth" or "competencies."

In the 1960s, subject-centered and learner-centered approaches were regarded as equally viable. The focus in new math, for example, was clearly on propositional and procedural knowledge derived from the discipline. The premise was, "Teach the structure of mathematics and all else will fall into place" (Cooney 1987, p. 2). In science, by contrast, much of the innovative curriculum was process oriented, aimed at providing students with general inquiry or problem-solving skills (Bredderman 1983). Correct performance of the "scientific method" became an end in and of itself (Smith and Neale 1991). It was assumed that content knowledge and conceptual understanding would follow naturally from a correct application of the inquiry process.

Changes in Epistemological Assumptions

In the past few years, scientists have become increasing critical of the epistemological views underlying the 1960s reform. The tendency to separate content and process, evident in much of the curriculum development work during the 1960s, is harder to justify in light of the epistemological views set forth by Kuhn (1970, 1977), Toulmin (1961, 1972), and others. It now appears that the relationship between content and process is more complex and interactive than originally thought. As Phillips and Soltis (1985) explain, "The methodology of a discipline is so much affected by the concepts and theories that are current that the attempt to separate them is completely artificial" (p. 59). The application of inquiry or problem-solving skills to the understanding

of certain phenomena does *not* yield information (i.e., facts, concepts, principles) that somehow is neutral with respect to theory.

The notion of "disciplinary structure," also popular during the 1960s reform movement, has received its share of criticism (Cherryholmes 1988). Critics of this concept argue that there is no such thing as *a* disciplinary structure. There are several different ways of ordering knowledge in a discipline, each with its own set of adherents. The idea of disciplinary structure has given way to a more relativistic view. The argument goes something like this: Disciplines can best be thought of as living entities, "bodies of knowledge that are in constant flux, growing and changing" (Phillips and Soltis 1985, p. 59). What is accepted as knowledge varies, depending on the particular historical-cultural context. Knowledge claims are the product of a social process (Benson 1989); while they can be defended, they cannot be proved. Thus, any acceptance of knowledge claims must be tentative. When good reasons for accepting a knowledge claim can no longer be marshaled, the claim is refuted. What constitutes a good reason, or argument, is a matter of opinion, although those within the discipline tend to agree about how such arguments should be structured. Nevertheless, in all the disciplines, there is considerable room for the exercise of judgment and creativity.

Constructivist views of teaching and learning reflect these important changes in how we view disciplinary knowledge. For this reason, if for no other, they differ dramatically from the subject-centered and child-centered perspectives that have guided discourse for most of this century. This makes the current reform effort very different from its predecessor 30 years ago. In the remainder of the article, I will focus on several widely held views about teaching and learning; I will explain why, as a constructivist, I take issue with many of these commonsense notions—and I will try to make a case for an alternative set of beliefs that are more conducive to promoting conceptual understanding in students.

Changes in Teachers' Views about Teaching and Learning

Because constructivism is relatively new on the educational scene, many of its implications have yet to be spelled out. This is particularly true in the case of constructivist views of teaching. At this point, these views are considerably less developed than are constructivist views of learning. This partly reflects the fact that researchers in the two domains are pursuing somewhat different agendas. Learning theories tend to be descriptive, theories of instruction, prescriptive; as a result, one cannot directly inform the other. As Cobb (1988) cautions, "Although

constructivist theory is attractive when the issue of learning is considered, deep-rooted problems arise when attempts are made to apply it to instruction" (p. 87). Most of the problems associated with implementing a constructivist approach to teaching could be overcome if teachers were willing to rethink not only what it means to know subject matter, but also what it takes to foster this sort of understanding in students. This is a tall order. Such change is unlikely to occur without a good deal of discussion and reflection on the part of teachers. Identifying what is problematic about existing beliefs, however, is an important first step in the change process.

One additional point should be made: While the interpretation of constructivism presented in this article is based on some of the best current thinking and research in the field, I cannot claim to speak for all those who embrace this particular approach. Like existentialism, constructivism is open to many interpretations. The arguments presented below will have served their purpose if they provoke further discussion about important issues relevant to teaching and learning.

The Learner and the Content Viewed as Separate and Fixed Entities

This section deals with the way teachers typically view the learner and the content. As a number of educators have pointed out, teachers tend to think of these two variables in static terms, as givens that somehow must be adjusted to in their present form. This is particularly true of the learner, as witnessed by the prevalence in teacher discourse of various trait descriptors—like "high IQ" or "low self-esteem"—presumably referring to general attributes thought to have relevance across specific settings and subject-matter domains. Because the curriculum consists of its own set of fixed demands, teachers are often in a quandary about how to proceed: Should one assign top priority to the learner's "needs" or to those of the curriculum? Unable to serve two masters at once, most teachers emphasize one or the other factor in their instructional planning (Brady 1986).

This separation of learner and content is highly problematic. Fortunately, there is an alternative: I will argue in this section for an interactive approach to instructional decision making that assigns equal weight to judgments about what students need to know and how they are construing that knowledge. In this sense, I will be elaborating an argument made nearly 90 years ago by Dewey ([1902] 1966). At that time, Dewey complained that many educators were overly rigid in their views about both child and curriculum. Many teachers, he pointed out, perceive the child's experience as something "hard and fast";

similarly, he noted, teachers tend to conceive of subject matter as "something fixed and ready-made, outside the child's experience" (1966, p. 11). Dewey urged educators to abandon these notions in favor of a more complex, interactive perspective, one that regards the child and content as "simply two limits which define a single process" (1966, p. 11). Consistent with current constructivist thinking, Dewey's feeling was that teachers should focus much more on students' attempts to understand particular aspects of the subject matter. In this section, I will discuss two factors that contribute to the adoption of a noninteractive or nonconstructivist perspective: the important role assigned to generic individual differences in our educational thinking, and the failure to come to terms with traditional views about the nature of knowledge—not only on the part of teachers, but also on the part of teacher educators and researchers.

The importance of individual differences.—Resnick (1981) maintains that two fundamental assumptions have governed American psychology: the biological assumption, which has led to an emphasis on respecting the course of the youngster's development and lessened interest in artificial environments (i.e., culture, schools), and the individualist assumption, which accounts for our compelling interest in the role of individual differences. These notions, as applied to education, have tended to move American education toward the child side of the child-content divide. Resnick maintains that developmental and differential psychology has convinced educators that it is futile to try to change or modify the course of development; the best we can hope to do is get in sync with it. This involves relatively minor adjustments in the timing and the breadth of content coverage.

Among researchers, interest in individual differences appears to be on the wane; this judgment is based on a comparison of the amount of attention this topic receives in educational psychology textbooks today as opposed to several years ago (Ash and Love-Clark 1985). Interest in individual differences on the part of teachers, however, appears to be holding steady and may actually be increasing, despite the fact that there is very little research base for much of what is included under this rubric. "Learning styles" is a case in point. This construct supposedly refers to the method of introducing material—not to the type of understanding one wants the child to gain (Levy 1983). Children are thought to vary in their approaches to learning, with most evidencing a preference for one of three channels or modalities (i.e., vision, audition, and kinesthesia; Barbe and Milone 1981). Dunn argues, on the basis of scant research (see Dunn 1983; Dunn and Carbo 1981), that it is best for students to learn, and be tested, in their preferred modality. Thus, children who feel they learn best through

auditory perception should be tested by having questions read aloud to them. Similar work on hemispheric specialization—the notion that some children are left-brain thinkers while others make greater use of the right brain—also appears to have struck a responsive chord in teachers (Hart 1986).

The problem with this view of individual differences, as Monk and Simpson (1989) point out, is that it is *noninteractive*. It is assumed that students have "essentially fixed approaches to things, and teachers must accept this" (Monk and Simpson 1989, p. 5). These fixed approaches are thought to be symptomatic of differences of a more basic sort—neurological, maturational, or cultural (i.e., located in the home or community). The important point, however, is that both symptoms and causes are regarded as generic in nature—and thus are seldom linked to differences in students' sense making in specific subject-matter domains or in specific learning contexts. What, after all, does IQ tell a teacher about a first grader's grasp of numeration? If teachers downplayed the importance of individual differences in instruction, the negative effects of this way of thinking about students would be negligible. Unfortunately, this seldom happens. Teachers, at least in this country, place a great deal of emphasis on fixed approaches in their instructional planning and their teaching. In fact, American teachers may be extreme in this regard.

Stevenson (1989) found that teachers in this country assign much more importance to individual differences, defined generically, than do Asian teachers, who tend to place their highest priority on content-related factors, such as the ability to explain concepts clearly. Stevenson's finding is consistent with the results of several studies that have examined the content of teachers' interactive thoughts during instruction: This research reveals that a surprisingly small percentage of teachers' statements about their thoughts during instruction relate to content or subject-matter factors (5–14 percent across three studies; Clark and Peterson 1986). Teachers tend to focus a great deal on learners, but they seem more concerned with whether the message is being received (i.e., heard or seen by students) than with what sense students are making of it once delivered.

A preoccupation with individual differences, I submit, has led to a *de-emphasis* on subject-matter concerns. As a result, little attention is devoted to difficult issues of content selection and understanding. Because individual differences are considered to be so pervasive, coloring the way students process nearly all content, teachers are driven toward a kind of mindless eclecticism in their instructional style. Many believe that the best way to accommodate individual differences is to employ a variety of presentation methods (i.e., both lecture and hands-on

approaches) and to involve students in a number of different learning contexts (i.e., large group, small group, and individual). This is not entirely wrongheaded, but it does lead teachers to emphasize the packaging and delivery of content (what might be termed the "Federal Express" approach). Difficult decisions about what ought to be "sent" and whether or not the recipients are making adequate use of it are assigned a lower priority. When curricular adjustments are made, they tend to be more quantitative than qualitative. Enrichment programs are a case in point. As Resnick (1981) points out, most of these programs are designed to provide gifted children with *more* skill or information—but at their normal grade level.

Individual differences are approached differently from a constructivist perspective. As indicated earlier, a focus on student thinking or sense making is the defining feature of this approach. Thinking, of necessity, is highly contextualized. It deals with a specific subject and takes place in a specific setting: As McPeck (1981) reminds us, "Thinking is always *about* something. To think about nothing is a conceptual impossibility" (p. 3). It follows from this that the type of individual difference that most matters from my vantage point as a constructivist is that which is most relevant to these two concerns—subject matter and setting. Thus, the focus must be two-sided: First, the teacher should attend to the diversity of understandings students develop when wrestling with important ideas in the specific subject-matter domain. The assumption here is that conjectures about student thinking are an integral part of the lesson-planning process (Lampert 1989). Second, the teacher should carefully attend to how individuals interpret various context variables, like the norms of discourse that prevail in the subject-matter domain. This particular factor plays a key role in influencing the extent to which students are willing and able to express their ideas during instruction (Cobb et al. 1988; Prawat 1989*b*). If the norms are viewed in such a way that students feel at risk when venturing opinions, they are much less likely to participate in classroom discourse.

The disposition and capacity to attend to subject-matter and setting variables on the part of teachers are not constructed out of whole cloth. In addition to a much more differentiated, as opposed to static, view of the learner, content knowledge appears to play an important role in this regard. Current research supports the commonsense notion that teachers are better able to assess student understanding when they are more knowledgeable about the topics they are teaching (Hashweh 1985). This most often is referred to as knowledge *of* subject matter; it entails an understanding of the substance of the discipline—that is, of the ideas that are considered most central or core

to those within the discipline. While knowledge *of* subject matter plays a vital role in bridging the gap between child and content, knowledge *about* subject matter may be of equal or greater importance (Ball 1991).

The role of knowledge about content.—Knowledge *about* subject matter includes the epistemological assumptions one makes about a particular domain of inquiry, that is, assumptions about the origin of knowledge, how it changes, and how truth is established within the disciplinary domain. Teachers have surprisingly strong beliefs about many of these issues, and this appears to influence their views about teaching and learning (Madsen-Nason and Lanier 1986; Smith and Neale 1989). Knowledge about subject matter—particularly the notion that content "moves," that it is continually being regenerated and modified by practitioners within the discipline—appears to play a key role in legitimating the diversity in student understanding. An illustration might be helpful.

I have been interviewing teachers in several research projects being conducted at Michigan State University in an effort to determine how various teacher education programs affect practice. One teacher, expressing her dissatisfaction with a math in-service program she recently attended, revealed a great deal about how she views mathematics. The teacher said she had trouble accepting the constructivist view of math learning being promulgated during the in-service program: "The way I had been taught math, it's supposed to be cut and dry. Two and two equals four all the time. With this new program, if you want to say two and two equals five, it's fine as long as everybody says it's going to be five." (The organizer of the program disagrees with this characterization. The program does attempt to challenge teachers' assumptions about the learning of mathematics. The aim, however, is to encourage teachers to teach in a way that involves students more directly in the learning of important mathematical concepts.)

The view of mathematics expressed by the teacher quoted above appears to be more the norm than the exception. Many of the teachers I interviewed seemed willing to defer to the "experts" when making curricular decisions. One teacher provided the following rationale in explaining why she felt she had to stick to the textbook, "I feel that, whoever all these authors are who came together to write this book, they must be whizzes at math, and therefore they know how to bring the level of math along in stages, within each concept." It was very hard for her, she said, to feel confident in exercising her own judgment about content. When teachers do decide to depart from the standard curriculum, they frequently second-guess themselves, worrying that it might create problems for the child later on: "I don't want to eliminate

anything," one teacher noted, "with the idea that it's going to come back and haunt these kids." Not only is knowledge fixed, there is one best way to fit the elements together.

As indicated earlier, this static concept is in striking contrast with current epistemology, which views the generation of disciplinary knowledge as a social process carried forth by communities of discourse. King and Brownell (1966) argue that "a discipline is a working, flourishing establishment" (p. 69). Although the process of change is social, resulting in a new set of ontological commitments on the part of members of the disciplinary community, it is not necessarily gradual, especially in science. According to Kuhn (1977), scientific development is often revolutionary, reflecting dramatic conceptual shifts of the sort that occurred when Galilean physics replaced Aristotelian physics. Several individuals have likened this process of conceptual change in the history of science to the process of conceptual change in the individual (Carey 1986; Carlsen 1987). Revolutionary science is akin to Piaget's notion of accommodation, in which an individual's cognitive structure is modified to fit new information. Normal science (Kuhn 1970), in contrast, is less dramatic (although no less important); it is analogous to the process of assimilation—the incorporation of new information into an existing structure.

Teachers who have a conceptual-change view of disciplinary knowledge are more inclined to think of the learner in constructivist or interactive terms. Thus, Smith and Neale (1989) observed a negative relationship between teachers' views of science—the extent to which they viewed content as lying outside the child—and their attentiveness to children's ideas and explanations during instruction. Similarly, Pope and Gilbert (1983) found that science educators who had absolutist views of truth and knowledge tend to place little or no emphasis on the students' own conceptions during instruction. In a subsequent piece, Pope and Scott (1984) suggested that teachers with absolutist conceptions of science are more traditional in their approach to instruction because they see no reason not to transmit directly what is perceived to be a collection of substantiated facts.

Thompson (1984, 1985), in a series of case studies of junior high school mathematics teachers, also noted a relationship between individuals' conceptions of mathematics and their classroom practice. Three teachers were observed extensively and interviewed over a four-week period. Only one of the teachers held a dynamic view of mathematics, seeing it as a discipline that is continually undergoing change and revision. The other two teachers conceived of math as a static body of knowledge. It is not surprising that these teachers tended to present the content as a finished product. They firmly believed that students

learn by carefully attending to the teacher's demonstrations and explanations and responding to her questions. The teacher with the dynamic view of subject matter, in contrast, departed from this teacher-centered scenario, emphasizing instead the importance of student reasoning in mathematics. She felt that teachers should encourage students to express their own ideas; this not only supports students' efforts to make sense of the content, it also provides a window into their minds. Thompson (1984) writes that, of the three teachers, only the one with a dynamic view of subject matter "showed signs of acute perceptiveness of the students' needs and difficulties during the lessons. Only she showed a tendency to capitalize on the students' unexpected remarks, incorporating them into the mainstream of the lesson or shifting the discussion to clarify the students' difficulties" (p. 121). As argued earlier, attentiveness to student cognition is one of the defining features of constructivist teaching.

In light of these data, one might argue that teachers' epistemological views (i.e., knowledge about the discipline) constitute the major impediment to the development of an interactive perspective, exerting relatively more influence in this regard than the other two types of knowledge/belief discussed in this section (i.e., views of the learner and knowledge of content). This, however, is an overly simplistic analysis. It is the *interaction* of these various types of knowledge/belief that allows the teacher to take an interactive stance (Hashweh 1985).

The Interaction of Views about Content and Views about Students

Roth (1987) presents an interesting case study that supports Hashweh's (1985) claim. The teacher she describes—a middle school science teacher—appeared to be an excellent candidate for a conceptual-change, constructivist intervention. He had a well-developed understanding of the scientific content to be taught. He could easily relate scientific concepts to phenomena that students were likely to encounter. In a unit on photosynthesis, for example, he was able to explain how the tapping of sugar maple trees was made possible by the food-making capacity of plants. He also possessed a sophisticated, conceptual-change view of disciplinary knowledge. At one point while talking about a key experiment in science, he discussed the role that anomalous results play in getting scientists to change their conceptions. This teacher was even able to pinpoint some of the misconceptions that interfere with student learning. He predicted that students would likely infer that plants got their energy from the soil because their root system was in the soil.

Despite all of this sophisticated knowledge and exposure to a set of curricular materials that linked student responses to conceptual-change teaching strategies, Roth's (1987) teacher was unable to abandon his traditional approach to instruction. Roth attributes this failure to the teacher's static conception of the science learner: He was convinced that the majority of his students would not be able to fully understand the science concepts he was teaching. Student misconceptions were interesting to him, Roth (1987) concludes, but they did not strongly influence his way of thinking about learning: "Instead, he thought about student learning in terms of student ability" (p. 36). Students who had ability would make sense out of the content. The others would pick up bits and pieces—and maybe learn the importance of good study and organizational skills.

Roth's case study illustrates the complex interaction that exists between knowledge about child and knowledge about content. A nice example of this type of thinking is presented in another paper by Roth (1989). In discussing her own science teaching, Roth talks about the trouble her fifth-grade students had in understanding a simplified explanation of the digestive system in a unit on body systems and how they use energy: They could describe how food moved through the intestines but could not imagine how it got into the bloodstream. Realizing that students' "front door/back door" way of conceptualizing the process was getting in the way, Roth (1989) decided to introduce the notion of permeability. As she explains, "I taught the students the word *semi-permeable* to describe cell membranes and the small intestine wall. This word and the notion of a screen became meaningful to most students. It was not until they had this information that they could make sense of the simplified explanation that 'food goes out of the small intestine and into the blood and then to the body cells'" (Roth 1989, p. 29).

The example presented by Roth highlights an important dilemma in constructivist teaching. On the one hand, it is important that teachers feel an obligation to the discipline. After all, it is the ability to access powerful ideas developed within the discipline that separates the expert from the novice (Prawat 1989*a*). On the other hand, it is important that teachers honor the student's own effort to gain meaning—even when it reflects less mature understanding. It is counterproductive for teachers to expect too much from the novice. Thus, teachers must strike a balance between their obligation to the discipline and their obligation to the learner. This frequently means settling for partial or incomplete understanding on the part of students. Carlsen (1987) provides an example: In guiding students toward an understanding of photosynthesis, the teacher might target an intermediate level of understanding (e.g., "plants make food using sunlight, water, air, and

minerals"), but only after carefully weighing where students are in their thinking (e.g., "plants get their food from their roots") and what would be considered a more adequate explanation from a disciplinary perspective (e.g., "plants make their food from carbon dioxide and water using sunlight"). Lochhead (1985) discusses this type of interactive thinking on the part of teachers:

> The question for educational developers is to determine which easily accessible intermediate states form effective bridges to expert performance. These investigations will be complicated by the recognition that the search involves the intellectual lives of students. When the intermediate state turns out to be a side track, rather than a bridge, it may not be easy to return. Students may be left with incorrect notions that were taught them in the hope of enabling them to move on beyond. But we must not be put off by the naive notion that current methods of instruction are any less dangerous. Research clearly shows that students often misconstrue the "clearest" presentations. [P. 6]

As the above quotation indicates, the content that students interact with should meet two criteria: It should be accessible, but it also should be powerful and "correct" in the sense that it meets certain disciplinary standards (Resnick 1987*a*). Striking this balance between what one can realistically expect of the learner and what those within the discipline might regard as legitimate knowledge is difficult. It requires a sophisticated understanding of students *and* of the content they are being asked to learn. Static views about either will serve as an impediment to this type of interactive thinking.

In the next section of the article, the focus is on one way to resolve the dilemma just discussed: that is, to trust the learner; he or she is in the best position to decide what is most needed at any particular point in development. The teacher's role, according to this set of beliefs, is indirect. The key task is to watch over the environment, ensuring that it affords enough opportunity for students to be involved in interesting and engaging educational activity. A popular version of this notion, which might be termed "naive constructivism," is discussed below.

"Naive" Constructivism

As indicated, naive constructivism boils down to a kind of faith on the part of teachers in the ability of students to structure their own learning. Like the noninteractive view discussed above, this belief gets in the

way of teachers developing a more constructivist view of teaching and learning. We recently interviewed an elementary school teacher who expressed this view when she said, "As long as children are active, then learning is going on." This sounds like a reasonable hypothesis; if one digs deeper, however, one can detect problems with this perspective, problems that Dewey pointed out more than 50 years ago.

In a series of lectures delivered in the late 1930s, Dewey ([1938] 1963) took issue with the notion that activity approaches are inherently better than more traditional approaches. Dewey's admonitions were based on his experience with progressive schools, where his theories were supposedly being applied. He was concerned that the pendulum had swung too far in the direction of a "development from within" view of education. He felt this was attributable, in part, to a misinterpretation of his position on the importance of experience in education. Many educators, in attempting to implement his theory, downplayed the importance of the *educational* value of experience, emphasizing instead its *enjoyment* value. Dewey (1963) considered this a distortion of his views: "Instead of inferring that it doesn't make much difference what the present experience is as long as it is enjoyed," he wrote, "the conclusion is the exact opposite" (p. 49). Experiences must be carefully selected and structured. Dewey emphasized that it is the educator's business to determine where an experience is heading. Subject-matter knowledge can play a key role in this regard. The teacher should draw on this knowledge to help students make sense out of their present life experiences. The attempt to connect subject-matter knowledge with the child's experience is the hallmark of Dewey's approach to education, contrasting sharply with traditional approaches that often start with facts and concepts outside the youngster's range of experience.

Dewey (1963) stressed how important it is for teachers to build on students' present experiences, but he emphasizes that this is only the beginning. "Finding material for learning within experience is only the first step," he writes. "The next step is the progressive development of what is already experienced into a fuller and richer and also more organized form, a form that gradually approximates that in which subject-matter is presented to the skilled, mature person" (Dewey 1963, p. 74). Additional experiences are necessary, but they must contribute to the growth of subject-matter knowledge. Too often in progressive educational environments, Dewey said, activities or experiences are not judged relative to this educative standard. There is little continuity from one activity to another or much of a sense of where an activity fits in the total scheme of things.

Dewey thus identified a persistent problem. It is exacerbated by the importance assigned to activities or experiences in teacher thinking

about instruction. Yinger (1977), for example, found that activities as opposed to ideas are the basic units and starting points for many teachers when they plan lessons. According to the analysis presented here, this problem—the tendency to equate activity with learning—can be attributed to a belief on the part of many teachers that student interest and involvement in the classroom is both a necessary *and* sufficient condition for worthwhile learning.

As will become evident, activity, or, more precisely, "authentic activity," can play an important role in the learning process. This role appears to relate more to cognitive than affective goals in education, however. Before elaborating on this notion, it would be helpful to examine a third set of beliefs, those relating to current views about the learning and application of knowledge. As a constructivist, I question the tendency to separate these two processes. How one resolves the transfer issue has far-reaching implications for a host of related issues, like what constitutes the most important resource for promoting thought in students—skills or ideas—or the extent to which modeling versus discourse strategies ought to be given preference in promoting understanding in the classroom. Transfer is the focus in the next section of the article.

The Separation of Learning and Application, Understanding, and Problem Solving

The tendency to separate learning and application, understanding, and problem solving has been legitimized in educational discourse in a number of ways. Two of the main sources of this legitimacy are Bloom's (1956) taxonomy and the literature on transfer. The fact that these two sources are mutually supportive is not a coincidence. Bloom's taxonomy was developed with the transfer literature in mind. Bloom hoped that the research on transfer would validate his taxonomy (see Bloom 1956, pp. 15–20). Most educators assume it has. As a constructivist, however, I question this assumption. I believe that current views of transfer are problematic on two counts: First, it is unclear how much real transfer occurs as a result of our current educational practice; second—and this helps explain the first problem—prevailing views of transfer are based on faulty assumptions about knowledge and learning.

Lave (1988) comments on the first of these issues: "When we investigate learning transfer directly across *situations*," she writes, "the results are consistently negative, whether analyzing performance levels, procedures or errors" (p. 68). There is considerable basis for Lave's

pessimistic assessment. For example, several recent studies show that youngsters have trouble applying even relatively simple skills, such as those involved in math computation, when the problems they are asked to solve are changed in subtle ways (Larkin 1989). Thus, in three-digit subtraction problems, students often forget to subtract from zero when borrowing across this number—even though they can correctly solve problems when digits other than zero are in the middle position.

Many educators account for results such as this by pointing out that the type or level of learning is a key factor influencing transfer. According to this argument, higher-order skills and abilities, those thought to mediate important processes such as problem solving and critical thinking, are more apt to transfer to other parts of the curriculum or to out-of-school performance than lower-order, factual and procedural acquisitions. Surprisingly few studies have tested this possibility; most have been content with showing that students improve on the tasks they were taught. Those that have examined higher-order transfer have yielded disappointing results. This, at least, is Resnick's (1987*b*) conclusion after reviewing a number of studies on problem solving and critical thinking. She found little empirical evidence to support the contention that these skills generalize to other contexts. Larkin (1989) agrees with this assessment, calling the focus on general problem solving skills and abilities "historically unproductive" (p. 302). Recent research thus raises doubts about our ability to produce transferable general skills and abilities in students, at least using the techniques we normally employ in formal education.

The fact that transfer is so difficult to produce provides some incentive for altering our views about this phenomenon. A major change in perspective on the part of either educators or researchers is unlikely to occur on the basis of research evidence alone, however. This, at least, is Lave's (1988) conclusion: "There is no impatience," she writes, "no hint in this work, that the meager evidence for transfer garnered from a very substantial body of work might indicate that the concept is seriously misconceived" (p. 39). This tolerance is probably due to the fact that current views of transfer map nicely onto current views of teaching and learning. More needs to be said on this point.

Vertical and Horizontal Transfer

There are two widely accepted, competing views of transfer. One, termed "vertical transfer," is concerned with the effects of one type

of learning on another. According to this view, transfer is the process that facilitates movement from lower-level, specific acquisitions (i.e., mastery of simple facts and skills) to higher-level, more general learning outcomes within a particular domain. In other words, the mastery of simpler knowledge or skills (e.g., spelling and grammar) paves the way for the acquisition of more complex knowledge or skills (e.g., complex writing).

The second type of transfer, termed "lateral" or "horizontal transfer," results in a kind of ripple effect, in which a specific skill or piece of knowledge influences an individual's behavior in a broad set of situations that are roughly at the same level of complexity. As the term implies, this is a test of the breadth of learning. Supposedly, this is what makes it possible for individuals to apply in one setting what has been learned in another. An example might be a chess master who applies the principle "control the center" in situations other than those involving a chess game—war or politics, for example (Perkins and Salomon 1989). Another example would be a general problem-solving skill such as means-ends analysis that (presumably) can be applied in a wide range of out-of-school contexts. If vertical transfer can be thought of as a "specific-to-general" process, lateral transfer is more of a "general-to-general" process.

Buswell (1942) was one of the first to note that issues relating to vertical transfer are of key concern to those favoring a subject-centered approach to instruction, while issues relating to lateral transfer figure more prominently in the thinking of those advocating a child-centered, problem-oriented approach to instruction. Katz and Chard (1989) reinforce this notion, although they prefer the term "relevance" to that of transfer: "Vertical relevance," they state, "refers to instruction that prepares the learner for the next level of instruction—a kind of education 'for the next life.' Horizontal relevance refers to learning that equips the learner to solve current problems within and outside the classroom or school" (p. 4). As indicated earlier, I question the assumptions that underlie both of these views of transfer.

Vertical transfer is based on a hierarchical view of learning. The mastery of certain prerequisite, lower-order facts and skills is thought to be a necessary if not sufficient condition for the development of more complex understanding and application-oriented learning. The pyramid is an apt model for this view of learning. Neither the model nor the view, however, fit well with recent constructivist views of the learning process (Prawat 1989*b*). Resnick (1987*b*) writes that cognitive research in areas such as reading and mathematics challenges the assumption that there is a sequence from lower-level activities to higher-

level ones. She concludes, "The term 'higher order skills' is probably itself fundamentally misleading, for it suggests that another set of skills, presumably 'lower order,' needs to come first" (p. 8).

I am just as dubious about some of the arguments supporting lateral transfer (Brown et al. 1989*b*). Particularly problematic are views about the role of context in this type of learning. Lateral transfer supposedly is mediated by a process of generalization. As Pea (1988) points out, this notion is based on "common elements theory," a view in psychology that dates back to Thorndike and Woodworth (1901). According to one version of this theory, transfer is the result of a kind of abstracting or context-stripping process: When one encounters the same concept or skill in different contexts, the specifics drop away. Transfer is only successful to the extent that these specifics ("contextual barriers") can be overcome (Gick and Holyoak 1980). Transfer thus involves *dis*-connection—quite literally, the separation or lifting of knowledge from its situational context.

The major problem with this view from a constructivist perspective is that it assumes that knowledge is independent of the situations in which it is used and acquired, a premise that has been strongly challenged by constructivists (Brown et al. 1989*a;* Resnick 1989). Traditional views of transfer assume that knowledge is transported from one context to another. Lave (1988) calls this the "toolbox" approach to knowledge transfer: According to this perspective, knowledge is analogous to a set of tools; transfer occurs when the tools are carried from place to place. After being taken out and used, the tools are stowed away again in their original condition and moved to the next job. The tools do not change as a result of their being used, nor do the phenomena to which the tools are applied. Another noteworthy aspect of Lave's metaphor is that it assumes that knowledge tools are acquired in a context separate from their use. Learning or comprehension is thus distinct from application. This claim is particularly problematic from a constructivist viewpoint.

An Alternative View of Transfer

There is an alternative way of thinking about transfer that differs dramatically from the transport view presented above. In many ways, it is the mirror image of the abstraction or stand-alone model of transfer that has predominated in psychology. Instead of emphasizing the importance of *de*contextualization or *dis*connection in transfer, as does the traditional model, this alternative perspective stresses the importance of knowledge *connectedness*—the assumption being that knowledge is

more accessible, and thus more likely to be transferred to novel situations, when it is a central or integral part of one's cognitive structure. There is some disagreement about how best to measure the centrality of any particular element of knowledge (Phillips 1983; Greeno 1983); the most widely used technique relies on card sorts or other concept-mapping strategies to assess the extent to which a particular element is linked to or associated with other important elements in the individual's cognitive structure (Prawat 1989*a*). Despite methodological difficulties, cognitive psychologists assign great importance to this associative aspect of cognition. As Flavell (1971) points out, the concept of cognitive structure presupposes such connections or associations: "To apply the term 'structure' correctly, it appears that there must be, at minimum, an ensemble of two or more elements together with one or more relationships interlinking these elements" (p. 443). According to Polya (1973), the breadth and depth of the connections or associations between elements of knowledge may be as important as the extent of one's knowledge. Research contrasting experts and novices in a number of fields supports this contention.

Experts know more than novices, but their real advantage lies in the ability to access or lay hold of what they know—presumably because their knowledge is organized in a more connected or coherent fashion. Thus, the expert mathematician has no trouble seeing relationships between elements of knowledge that the novice might regard as separate or distinct: the relationship between rules for computing the area of a triangle and rectangle, for instance, or between fractions and decimals. As Skemp (1978) points out, this sort of "relational understanding" is harder to acquire; one must learn both the elements and the relations between elements. The effort seems worthwhile, however, because it leads to the creation of knowledge structures that are more accessible or lasting.

Constructivists have heightened our awareness of the importance of connectedness in knowledge acquisition and use. In the most straightforward model of knowledge organization put forth by these theorists—the so-called tinker-toy model—the system or structure consists mostly of "nodes" (i.e., elements of knowledge) and "connectors" (i.e., associative links; Clancey 1988). Several constructivists, myself included, have complicated this picture a bit by insisting that there are different types of nodes or elements of knowledge. Among the most prominently mentioned are the following: procedural nodes, which consist of skills and processes, of both an abstract and more mundane variety (comprehension monitoring and decoding are examples in reading); conceptual nodes, a category that covers an even greater range; representational nodes, which can take many forms,

including pictures, models, analogies, and metaphors—all intended to crystallize or give form to more abstract concepts and ideas; and, finally, informal or intuitive nodes, the often-idiosyncratic type of knowledge that individuals construct on their own, out of whole cloth as it were. Within each category, some elements of knowledge are regarded as more meaningful than others—which is to say, they allow for a richer set of connections within the structure (Prawat 1989*a*).

While recognizing that knowledge elements can take many forms, constructivist research to this point has tended to focus on fairly complex procedural knowledge of the metacognitive skills variety. This work has been strongly influenced by the theorizing of Vygotsky, and by recent work on teaching and learning in everyday contexts (see Rogoff and Lave 1984). An attempt has been made to utilize instructional techniques that mimic those used successfully by more expert adults (i.e., mothers, master craftsmen) in real-life learning situations. Collins et al. (1989) cite three such strategy-oriented programs. Each manages to teach complex learning or problem-solving skills as a by-product of ongoing, authentic instructional activity. In the reading program developed by Palincsar and Brown (1984), for example, comprehension-monitoring strategies, such as summarizing and question asking, are modeled and practiced in a context in which participants share the real-world goal of deriving meaning from text. The fact that students are learning to apply the skills as they are being acquired is thought to be a key ingredient in the program's success. In the absence of such a "situated learning" context, Palincsar and Brown's program would consist of little more than an abstract set of principles (e.g., "Students should be encouraged to reflect on what they have just read").

The work cited above highlights an important type of connection: that between knowledge and context. I believe there is little reason to distinguish between this type of connection and the more familiar type of knowledge to knowledge talked about earlier. *Both* contribute to knowledge organization, and thus to one's ability to access or utilize knowledge in novel situations. Despite its importance, contextual knowledge—the type of knowledge that results from our attempts to use what we know—is often devalued in school. Brown et al. (1989*b*) wish to remedy this situation. They make a strong case for changing teaching practice to create more opportunities for students to engage in "authentic activity" in the classroom. Only when students engage in this sort of activity, they believe, will they gain access to the insights that enable practitioners to act meaningfully and purposefully. The term Brown et al. (1989*b*) use to describe this sort of experience is "situated learning."

Situated learning.—Brown et al. (1989*b*) have severe doubts about the viability of the distinction between learning and application, understanding and problem solving. They maintain that the application or use of knowledge contributes to its development and vice versa. Their argument goes something like this: When a skill or concept is used in a specific situation, it acquires meaning that it did not possess before. The situation thus becomes an important part of what one knows or understands about the particular skill or concept; to use their words, the knowledge is recast "in a new, more densely textured form" (Brown et al. 1989*b*, p. 33). Because of the importance Brown et al. (1989*b*) assign to contextual knowledge, they show a clear preference for approaches like Palincsar and Brown's that embed learning in real-world activity. Such approaches, they argue, are more consistent with current theory and research in cognitive psychology.

The contribution that contextual knowledge makes to one's overall understanding is illustrated in a study by Carraher (1986). She contrasted the performance of students and construction foremen on a series of scale-conversion problems. Subjects in both groups used the same procedure to calculate the target dimensions on a blueprint drawing. Even though they approach the task in a similar way, students made significantly more errors, most of which were of the "nonsensical" variety, than foremen. Students, for example, often placed decimals in the wrong place, thus winding up with wildly inflated answers. None of the foremen made this kind of mistake, presumably because they possessed enough real-world knowledge about the task to judge the reasonableness of certain outcomes. Students typically lack this kind of experience. Furthermore, the sorts of things they are asked to do in school do not easily map onto authentic out-of-school activities or performances.

What students are typically asked to do within various subject-matter domains often bears little relationship to the kinds of activity engaged in by practitioners of the discipline. As Brown et al. (1989*b*) put it, "Many of the activities students undertake are simply not the activities of practitioners and would not be endorsed by the cultures to which they are attributed" (p. 34). At best, school is a hybrid, "implicitly framed by one culture [the school], but attributed explicitly to another [the discipline]" (Brown et al. 1989*b*, p. 34). "History," for example, often involves little more than the memorization of fact; "problem solving" in mathematics is frequently defined as the artificial search for syntactic cues in story problems (e.g., the word "left" as in "How many are left?").

Because context is so important, Brown et al. (1989*b*) suggest, it may make educational sense to begin with activities or situations, then

work back to the relevant skills or concepts. This is what is typically done in apprenticeship programs, where knowledge and skill are instrumental to the accomplishment of a particular task. In most apprenticeship programs, the novice works alongside one or more skilled practitioners, receiving guidance that is carefully tailored to his or her learning level. In such a social context, the novice acquires more than skill and knowledge. By participating in a culture that helps frame or provide an overall context for the activity, the apprentice acquires a belief system and a way of interpreting reality that is consistent with cultural norms. This type of learning occurs naturally through the process of enculturation. As Brown et al. (1989*b*) explain, "Given the chance to observe and practice in situ the behavior of members of a culture, people pick up relevant jargon, imitate behavior, and gradually start to act in accordance with its norms" (p. 34).

The teacher's task becomes more complex when enculturation is the goal. To provide students with a real sense of how practitioners view the world, teachers must create a classroom environment that is a "microcosm" of the disciplinary culture. Teachers can facilitate this process by playing the role of disciplinary practitioner—modeling the process a mathematician might go through in solving a problem, for example, or that of a historian in accounting for why a particular event occurred. The goal of enculturation is *not* to produce miniature mathematicians or historians; the purpose is simply to create a more meaningful educational environment (Brown et al. 1989*a*). Consistent with the notion of situated learning, the constructivists' argument is that skills like comprehension monitoring in reading are best taught in the context of their application to real-world problems or concerns (e.g., trying to extract meaning from an important piece of text).

As the above example suggests, the focus thus far in the work on situated learning has been on the acquisition of metacognitive skills and strategies. As I have argued elsewhere, however, this emphasis may be off the mark (Prawat 1991*b*). If a concentration on the "syntactic" or "how to" aspects of thought leads us to ignore more substantive issues (i.e., what it is that we want students to think about), then the focus clearly is counterproductive. Ideas, being more substantive by nature, may be a more important resource for promoting thought than thinking skills per se. Ideas (e.g., the concept of photosynthesis in science, or the notion of additive composition in elementary school mathematics) can and often do serve as valuable lenses, directing our attention to important aspects of the environment that otherwise might go unnoticed. Ideas play both an assimilative and accommodative role (Neisser 1976), allowing individuals to build on old information while continuing to search the environment for new information that leads

to increased understanding. Ideas are created through a social process—"the dialectical interplay of many minds, not just one mind," to quote Cobb (1989, p. 36). In this sense, a social-interactive model of learning is equally applicable to idea and skill learning (Moll 1990). As these arguments indicate, a strong case can be made for an approach to situated learning that is more conceptual than strategic in orientation.

Using ideas to describe and explain phenomena.—Each domain, such as history or science, deals with a certain set of real-world phenomena (Ennis 1989). Specialists within these domains have developed powerful concepts that are useful for describing and explaining these phenomena. Rather than provide these concepts or ideas to students in a decontextualized form, teachers could emulate researchers such as Palincsar and Brown (1984), embedding "big ideas" from the discipline in authentic activity: that of getting students to use the ideas in their attempts to understand specific, real-world objects and events. The result would be a kind of cognitive apprenticeship (see Collins et al. 1989), but one focused on *ideas* instead of *skills* or strategies.

Anderson and Roth (1989) propose something like this in science. They note that students rarely get opportunities to use scientific concepts and theories in a functional sense. Many teachers teach students about the conceptual tools of science, Anderson and Roth write, but they do not teach them how to utilize those tools. Rather than work on becoming more adept at using ideas from science to describe and explain scientific phenomena, students "practice primarily the activity of producing small bits of information on demand" (Anderson and Roth 1989, p. 269). Anderson and Roth (1989) report on their attempts to introduce situated learning into the classroom. They have found that teacher modeling alone—that is, teachers demonstrating to students how the ideas can be used to describe and explain phenomena—is insufficient for students to acquire the desired insight. They conclude that, regardless of how well the ideas are presented, they will not be understood unless students make personal use of them to understand important aspects of their world.

Brown and Kane (1988) obtained results with preschoolers that support Anderson and Roth's (1989) contention that youngsters need to "work" the ideas they are trying to understand. They presented stories describing various scientific phenomena (e.g., the use of mimicry as an animal defense mechanism). The specific cases were instances of a more general concept (e.g., some animals protect themselves from enemies by taking on the characteristics of scary animals). Students who were able to extract the general concept on their own, usually as a result of careful prompts by the experimenter, evidenced more recall and transfer than those who were simply told the concept.

In both of the studies described above, science was selected as the domain in which to test notions of situated learning. Domains such as science, which connect with objects and events in the world, could be better sites for situated learning than domains such as mathematics, which deal primarily with abstractions. Resnick (1988), however, disputes this. She points out that, even though mathematical statements deal with abstract entities such as numbers, lines, and points, they can still be mapped onto various real-world situations. Hoffman (1989), a professor of mathematics at the Massachusetts Institute of Technology, agrees. He defines mathematics as the science of patterns: "Its aim," he writes, "is to classify, explain, and understand patterns in all their manifestations—whether the patterns have to do with quantity, shape, arrangement, or form. Around this notion," he believes, "a practical philosophy of education can be built" (Hoffman 1989, p. 18).

The Social Context in Situated Learning

The social context plays a key role in all constructivist approaches to teaching and learning. This is particularly true when the focus is on ideas as opposed to skills or strategies. I have used the term negotiation to describe the type of social interaction that occurs in such a classroom (Prawat 1989*b*). This term can be defined in two ways. The first definition, "skillfully overcoming obstacles" (as in "negotiating the winding road"), is consistent with Brown et al.'s (1989*b*) view of the teacher as a kind of expert guide who helps students as novices traverse new cognitive territory while enculturating them into a particular disciplinary community. The second, more conventional definition, "reaching consensus on important matters," has particular relevance for an idea-oriented approach to situated learning.

According to this second definition, negotiation serves *two* important functions, both of which have the same goal: the development of a disciplinary "learning community" in the classroom. The first function is to establish norms of interaction to govern how members of the group relate to one another. It is important that individuals agree on the ground rules for classroom discourse, a factor that Lampert (1988*b*) and others stress in their discussions of constructivist approaches to mathematics teaching. From a constructivist perspective, it is essential that the classroom environment be perceived as one in which individuals are free to explore ideas, ask questions, and make mistakes (Cobb et al. 1988).

The second function of negotiation is to reach agreement periodically about disciplinary "truths." This not only provides necessary closure, serving as a kind of payoff for the effort expended to that point; the institutionalized knowledge that results from this negotiation process also provides a firm foundation for further work. It helps to minimize risk by establishing the sense of shared meaning necessary for interpersonal communication. (Of course, it is up to the teacher to ensure that the "truths" arrived at in the classroom are consistent with disciplinary knowledge.)

Transfer as a Function of "Connectedness"

It might be helpful at this point to pull together the separate arguments put forth in this section of the article. I have attempted to convince the reader that a dramatic change in our current view of transfer is in order. The central assumption that underlies this view—the notion that one typically learns something in one context and applies it in another—has been called into question by a number of constructivist researchers. I believe this approach to transfer is mischievous because it emphasizes the lifting of knowledge or skill out of one context (i.e., the learning context) before plugging it into another (i.e., the application context). The best way to facilitate transfer, I have argued, is to ensure that the particular element of knowledge is well learned to begin with. Current research suggests that this is best done by building connections—both of the knowledge-knowledge and of the knowledge-context variety—rather than through a process of *dis*connection or differentiation. The richness of the connections between elements of knowledge, including "indexical knowledge"—that is, knowledge that develops out of attempts to use knowledge (Brown et al. 1989*b*)—directly affects the accessibility of any aspect of knowledge in a novel situation.

The focus in the particular constructivist approach talked about above is on youngsters using "big ideas" to talk about quite specific aspects of their environment (e.g., "Use the concept of 'taxation without representation' to discuss the Boston Tea Party," or "Talk about this particular subtraction problem using the concept of exchange of value"). This model, powerful ideas applied to specific aspects of the environment, is much more likely to result in the acquisition of well-organized and highly transferable networks of knowledge in youngsters compared with the traditional model that is based on a clear delineation between

different types of knowledge (i.e., lower order/higher order), and between learning and application contexts.

Curriculum as Fixed Agenda

If teachers change their views about teaching and learning along the lines suggested above, it should lead to equally sweeping changes in how they think about curriculum. In fact, it is difficult to separate views about curriculum, teaching, and learning; all three reflect assumptions about what knowledge is of most worth and how one might go about teaching it. Most distinctions relevant to one set of views can be applied to the other two (Eisner and Vallance 1974). This certainly appears to hold for the ubiquitous subject-centered/learner-centered distinction discussed above. After considering how this distinction influences teachers' thinking about curriculum, leading to a fixed-agenda approach to instructional planning, I will present an alternative perspective in this section of the article that is more consistent with constructivist views of teaching and learning. According to this alternative perspective, teachers should discard the notion of curriculum as "a course to be run" and think of it more as a network of important ideas to be explored. This "open-systems" view of curriculum is consistent with current thinking in science, which is moving away from a stable, mechanical view of the world toward one based on notions of complexity and change.

Subject-centered versus Child-centered Views of Curriculum

Fifteen years ago, Eisner and Vallance (1974) published an influential book describing different conceptions of curriculum. Recently, Vallance (1986) discussed the merits of various reorganizations of the original set of categories laid out in that book. In one of these reorganizations, the five original categories are collapsed into two—those that focus on the individual child's capabilities and those that focus more on the content and delivery of curriculum. This simplified conceptualization bears an obvious relationship to the learner-centered/subject-centered distinction discussed earlier.

Vallance believes that her reanalysis would be strengthened by the addition of a third category, one that is more consistent with constructivist views of teaching and learning. The conception of curriculum that she wants to add focuses on a dimension of schooling that somehow got shortchanged in the earlier work. It is a commitment to the sheer

excitement of learning, described in this way: "It partakes of academic rationalism to the extent that it allows for and celebrates the intellectual territories of the traditional disciplines. It incorporates the self-actualization perspective to the extent that it celebrates the personal liberation that can come from understanding and appreciating the questions that the traditional disciplines ask—and from being able to synthesize them to appreciate a variety of modes of knowing" (Vallance 1986, p. 27).

In addition to questions of the worth and value of knowledge, which are dealt with by Vallance's most recent (1986) scheme, curriculum also deals with a pragmatic set of concerns relating to *how* knowledge is imparted to students. Curriculum planning is one area that falls under this rubric. A number of models have been developed to describe the curriculum-planning process. Brady (1982, 1986) has recently examined these models to determine to what extent they account for what teachers actually do when planning curriculum in two divergent disciplinary domains—math and social studies. She was particularly interested in how teachers think about the curriculum commonplaces (i.e., objectives, content, learning experiences, evaluation) as they engage in the planning process. She selected the two most prominent models of the planning process talked about in the theoretical literature and developed an instrument to measure the extent to which teachers were oriented more toward one or the other in planning curricula. The first of these Brady termed the "objectives model."

According to this approach, curriculum planning starts with a clear statement of the objectives one hopes to accomplish; all else follows from this. Proponents of this view recognize that objectives reflect value judgments. By focusing on the process of alignment, however, whereby each of the commonplaces is considered in relation to the one immediately preceding it, they can claim neutrality with regard to these more substantive issues. Once the ends are fixed, decisions about content, methods of instruction, and forms of evaluation can be made in a rational way. Closure is achieved by returning to the ends or objectives to see whether they have been carried out.

The second model identified by Brady (1986) is more fluid than the first; it contains the same elements but allows for considerable variety in their sequencing. This model is termed the "interaction model" of curriculum development. It appears to be more consistent with the learner-centered approach to teaching and learning. In this model, the developer can start at any point and move in any direction among the four curriculum elements. To illustrate, assume a developer has a firm commitment to a particular instructional approach, such as discovery learning. This might serve as a beginning point in the planning

process, helping to structure decisions about objectives, content, and evaluation. Alternatively, a particular view of the learner might drive the curriculum-planning process. Certain kinds of classroom activities would then be selected with this view in mind (e.g., hands-on activities to accommodate concrete learners). Decisions about content and evaluation would follow from these higher-priority decisions. The "interaction model" also allows for the progressive modification of elements during the planning process. Earlier decisions are frequently altered in light of later decisions.

Brady's (1982, 1986) research demonstrates that the models identified above do shed light on the process of curriculum development. She administered her questionnaire to nearly 300 teachers in 20 different elementary schools. Aggregating to the school level, she found a clear preference for the objectives model. This was true in both of the subject-matter domains tested—math and social studies. The relative advantage of the objectives model varied by subject matter, however. In 17 of the 20 schools, scores for the interaction model were higher in the social studies area than they were in mathematics. This finding is consistent with Stodolsky's (1988) characterization of differences between these two subject-matter domains: Math tends to be more teacher and subject centered, social studies more learner centered. By inference, then, Brady's results indicate that there is a relationship between teachers' orientations to curriculum planning and their views about teaching and learning, at least within subject-matter domains.

An Open-Systems Approach to Curriculum

As a constructivist, I consider both of these models flawed. Both are essentially "closed-systems" models, with the curriculum being viewed as a linear and well-defined course to be run. Regardless of the starting point, they constitute fixed agendas. In both approaches, the teacher's task is to keep things moving, to ensure that lessons unfold as planned. The teacher's primary role is that of manager or orchestrator. Consistent with the closed-systems metaphor, adjustments or regulations (in the form of teacher action) come from *outside* the system. Doll (1986) uses the example of hot water circulating in a house to illustrate what he means by a closed system. Any change in the way this process functions is seen as problematic, resulting in either chaos—water leaves the system and the furnace melts the pipes—or some external adjustment that helps correct the system (e.g., adding water to the pipes). In the traditional, subject-centered and learner-centered views of curriculum talked about above, the teacher is the external regulator, staying outside

the arena of action. As Doll (1989) points out, the notion of the teacher being above the fray fits well with the traditional view of science. While such a view is a thing of the past, according to Doll (1989), its specter still haunts the field of curriculum: "Far too often our curriculum is reductionist, and far too often this curriculum assumes the teacher to be a spectator in the arena of learning" (p. 248).

Doll (1989) notes that the closed-systems view of curriculum is based on an outdated, Newtonian model of the universe. Sawada and Caley (1985) make a similar point. They write,

> The dominant metaphor for today's education is the Newtonian Machine: The school is a more or less well oiled machine that processes (educates?) children. In this sense, the education system (school) comes complete with production goals (desired end states); objectives (precise intermediate end states); raw material (children); a physical plant (school building); a 13-stage assembly line (grades K–12); directives for each stage (curriculum guides); processes for each stage (instruction); managers for each stage (teachers); plant supervisors (principals) . . . uniform criteria for all (standardized testing interpreted on the normal curve); and basis product available in several lines of trim (academic, vocational, business, general). [P. 15]

At the end of the passage quoted above, Sawada and Caley ask rhetorically whether all of this is reminiscent of "Fords, Apples, and Big Macs?" According to Doll (1989), it is. He favors an open-systems approach to curriculum.

In an open system, perturbation or anomaly is regarded as an important stimulant for growth. Doll (1989) justifies such an approach to curriculum by citing cutting-edge work in science, particularly in biology and quantum physics. According to Doll, the new order in science is based on three important assumptions that could provide the foundation for a new approach to curriculum: internality, spontaneity, and indefiniteness. The first assumption highlights the importance of internal restructuring; it suggests that the students' ability to structure and organize their own experience should be the focal point in the curriculum. The second assumption highlights the nonincremental nature of this process. There is a rhythm and flow to learning; periods of equilibrium precede sudden disequilibrium. Students, like adults, need to mull things over in their minds—to try alternatives, to disagree, and to reflect. This promotes change. As Doll (1986) puts it, "Asking students to reflect on their actions, to explain why they did what they did, and to present their methodologies to open scrutiny is important" (p. 15). Lesson plans should be designed

to provide the right amount of disequilibrium and "re-equilibrium" in the form of closure to facilitate development (see above). In this regard, teachers need to carefully attend to student thinking in order to know when to challenge and when to be supportive.

A Curriculum Built around Big Ideas

The third assumption may be the most difficult to incorporate into the curriculum. If teachers took the notion of indefiniteness seriously, they would design curriculum differently. The clear distinction between ends and means, evident in the two models of curriculum development discussed by Brady (1986), would cease to exist. In traditional models, the teacher selects and organizes knowledge to match or align with predetermined outcome criteria. As a constructivist, I support a much more interactive approach, in which some of the important particulars of the curriculum emerge through a process of negotiation with students. I believe that it is the teacher's responsibility as expert to set broad goals, but that these should serve more as guides or beacons to help structure discourse. Curriculum thus would become a "multifaceted matrix to be explored" rather than a course to be run: "In this matrix, places where one begins and ends are far less important than how well one explores the myriad connections, logical and personal, inherent in the matrix" (Doll 1989, p. 251).

The matrix concept fits well with constructivist thinking. Both stress the importance of "connectedness" in learning. In fact, as indicated earlier, many researchers equate this variable with conceptual understanding, arguing that seeing relationships or connections between units of knowledge is the sine qua non of this type of understanding (Prawat 1989*a*). Research demonstrates that the expert's knowledge structure is more richly connected than that of the novice—but there is an ideational difference as well. The expert's knowledge base is organized around a more central set of understandings or "big ideas" than the novice's (Chi et al. 1981). Master teachers have long recognized this fact. Zukav, in his book on quantum physics entitled *The Dancing Wu Li Masters* (1984), emphasizes that "[the Wu Li master] begins from the center and not from the fringe. He imparts an understanding of the basic principles of the art before going on to the meticulous details, and he refuses to break down the t'ai chi movement into a one-two-three drill so as to make the student into a robot. . . . A master teaches essence. When the essence is perceived, he teaches what is necessary to expand the perception" (p. 4).

Viewing the curriculum as a matrix or network of big ideas represents a marked departure from the fixed-agenda concept. Practically, this involves a two-tier approach to curriculum planning. The first tier involves settling on two or three broad, general goals (e.g., "developing an understanding of how living things interact with other living things and with their physical environment" in science); once these have been specified, one can engage in the sort of conceptual analysis that yields a series of big ideas relevant to each major goal. In keeping with the constructivist view presented here, teachers need to be mindful not only of the ideas, but of the important relationships between ideas. In a recent paper, Lampert (1988*a*) stressed the importance of this sort of knowledge if teachers are to teach in a "constructivist" fashion (my term, not hers). Teachers need to know where the teaching and learning process is headed, but not in the traditional sense of one topic following another. It is more important that teachers develop a global view, understanding the network of big ideas that helps define a domain of inquiry, and possible relationships among those ideas.

Lampert (1986) provides an example of such a network in mathematics. Developing a principled understanding of multidigit multiplication requires understanding a number of big ideas, including the notion (*a*) that the way digits are lined up in a number has meaning, (*b*) that all quantities are compositions of other quantities, (*c*) that one can recompose problems into sets of more easily manipulated subproblems (e.g., 78 − 33 converted to a more solvable [70 − 30] + [8 −3]), (*d*) that the order in which multiplications are done does not affect the final product, and so forth. According to Lampert, these ideas form the foundation for a conceptual understanding of multidigit multiplication. If teachers are to move beyond teaching multiplication in a purely algorithmic way, they must attend to these sorts of big ideas.

Elliott (1988) elaborates on the notion of curriculum as a network of big ideas. Like Lampert, he suggests that we think of curriculum as a map—one that is arrived at interactively by taking into account both child and content. Thus, Elliott argues against the selection of ideas based solely on disciplinary grounds, independent of the pedagogical process. It is important, he believes, that the curriculum map be shaped *within* pedagogical practice. In this process, teachers must be responsive to the students' own "search for meaning" (Elliott 1988, p. 12), taking into account subjective factors such as the extent to which students seem challenged or stretched by the content. This attempt to validate the curriculum map requires a great deal of reflection and experimentation on the part of teachers. It is not an instant event, Elliott cautions.

The approach to curriculum that I favor is less structured than the traditional, textbook-driven approach. As noted above, this reflects the fact that the development of conceptual understanding typically follows a zigzag as opposed to a linear path. "If one is to teach in a way that promotes conceptual understanding," Lampert (1989) notes, "there is no clear starting place or sequence of lessons that is universally appropriate" (p. 50). Working from a curriculum map does not allow the teacher to predict what is going to happen, but it does allow the teacher to anticipate future possibilities (Elliott 1988). It provides teachers with a sense of direction without limiting their ability to explore the conceptual terrain with students. This view of curriculum thus fits nicely with the other constructivist views about teaching and learning.

Conclusion

An idea-oriented curriculum places more of a burden on teachers. There is a greater need for experimentation and self-reflection in implementing such a curriculum. In deciding which ideas from the discipline to emphasize, and how to situate those ideas in real-world phenomena, teachers must draw on several sources of knowledge, weighing not only what is most important for students to know from a disciplinary perspective, but also what students are best equipped to learn—and what they as teachers are best equipped to teach. In the constructivist approach to teaching and learning mapped out in this article, this information must be integrated. Clearly, there is more risk in such an approach, both for students and teachers, compared with traditional instruction. Is the risk worth the potential payoff? I think so.

There is good reason to believe that our current methods of instruction are inadequate and insufficient. In addition to the results of various international comparisons of academic achievement, numerous research studies show that students in this country often fail to understand even simple concepts in math and science. (One math educator, e.g., found that three quarters of the second graders he interviewed solved the following problem by simply adding the numbers 26 and 10: There are 26 sheep and 10 goats on a ship. How old is the captain? [See Reusser, cited in Schoenfeld, in press.])

The focus in this article has been on four sets of belief that serve as impediments to the adoption of a constructivist view of teaching and learning. These beliefs, I argued, underlie and legitimate widely held transmission views of teaching and absorptionist views of learning.

They thus are important candidates for conceptual change. These beliefs can be briefly described as follows: The first set results in a dichotomous view of the learner and of the curriculum. Instead of viewing students and curriculum interactively—as "two limits which define the same process" (Dewey 1966, p. 11)—teachers tend to regard them as separate factors that somehow must be reconciled. As a result, I argued, teachers focus on the packaging and delivery of content, instead of on more substantive issues of knowledge selection and construction. The second set of beliefs complements the first: the notion that student interest and involvement (i.e., in "hands-on activities") constitutes both a necessary and sufficient condition for worthwhile learning. The third set of beliefs, the long-standing distinction between comprehension and application, encompasses two particularly mischievous notions: the idea that learning is hierarchical, and that generalization leads to transfer. The fourth set of beliefs relates to the curriculum and goes hand-in-hand with the third: the popular view of curriculum as a fixed agenda, consisting of well-ordered content mastered according to predetermined criteria.

The fact that most teachers accept the problematic views described in this article helps explain why procedural norms predominate in teaching, at least at the elementary and secondary levels. The ability to *manage* curriculum, to *run* activities, to *organize* students are all thought to be crucial factors in accounting for a teacher's success. Obviously, the image of the classroom growing out of this view of teaching and learning is far removed from that held by most constructivists, who envision the classroom as a center of intellectual inquiry—a place where teachers and students engage in the in-depth exploration of important ideas from the different subject-matter domains. It is not my intent to paint an overly pessimistic picture of what is required if the current reform effort is to succeed. I hope that this discussion will not alter anyone's views about the need for, or the likelihood of, this reform happening. However, it is worth emphasizing that the sort of transformative change in viewpoint discussed in this article will require a great deal of discussion and reflection on the part of teachers. In moving toward a constructivist approach to teaching, teachers will need to attend to their own conceptual change at least as much as they attend to this process in their students. This will not be easy, and it is unlikely to occur without wholesale restructuring or reworking of the workplace. If teachers are to rethink teaching and learning along the lines discussed in this article, they must have the opportunity to participate in a learning community with other teachers and educators similar to the one they are trying to provide for their students.

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